Pullman Plant Materials Center

National Soil Health Study Progress Report – Year 1

March 2014

Pamela Pavek, Conservation Agronomist, Pullman Plant Materials Center

Introduction

The Pullman PMC is one of seven PMCs participating in a national Plant Materials Program study to evaluate the effects of cover crops on soil health. We planted the first year of the study in October 2012. Throughout 2013, we collected cover crop percent cover and biomass data; measured soil bulk density, soil moisture, and soil temperature; collected soil nutrient and biological indicator samples; and assessed commodity crop yield. We planted the second year of cover crops in the fall of 2013, and are currently tracking changes in percent cover. The cycle will repeat for a third year and end in 2015. Information gathered in this study will help us determine the adaptability of the cover crop species to the Palouse region and their effects on soil health, as well as their effect on commodity crop performance. This report summarizes our first year data.

Summary of Preliminary Results

- Cover crop plots were dominated by triticale, which had 58% to 93% cover at the time of termination.
- Hairy vetch had 12% to 19% cover at the time of termination in the 4 and 6 species mix plots.
- Red clover and oats established in the fall but did not survive the winter, and very few radish or rapeseed plants survived.
- The rate of cover crop growth increased substantially during the first two weeks of May, a period with record high temperatures.
- Cover crop plots produced 0.53 t to 2.27 t/ac dry matter biomass prior to termination, compared to 0.25 t/ac dry matter weed biomass in the control.
- Cover crop plots had 26% - 48% less soil moisture and 30% to 50% less soil nitrate than the control plots at the time of commodity crop planting.
- Barley yield was highest in the control plots, and was 60% to 85% lower in the cover crop plots.
- All cover crop plots had a decline in Soil Health Indicator Value except the plot with the 4 species mix seeded at the highest seeding rate (60 seeds/sq ft). This plot had the highest number of legume (hairy vetch) plants. It also had the lowest barley yield.

Materials and Methods

The study was conducted at the Pullman Plant Materials Center (PMC) near Pullman, WA. The area receives 20 inches MAP (15 inches actual 2012-2013 crop year) of which 70% is received in the winter and spring months, and has an average of 5650 GDD (base 32° F) per year. The study was planted in a field with Palouse silt loam soil and a south-facing 6% slope. The Pullman PMC is not irrigated. Cover crop mixes consisted of 2, 4 and 6 species seeded at rates of 20, 40 and 60 seeds per sq ft. All species in all mixes were planted in equal proportions based on seeds per square foot.

Cover crop mixes

2 Species: Triticale and red clover

4 Species: Triticale, red clover, radish, and hairy vetch

6 Species: Triticale, red clover, radish, hairy vetch, oats and rapeseed

There were 4 replications of each of the 9 treatment combinations in a randomized complete block design. The control plots consisted of no cover crop.

We seeded the plots with a John Deere double disk drill into a very dry, conventionally-prepared seedbed on October 3, 2012. We did not receive any precipitation during the months of July, August, September and the first 11 days of October. Our first significant rainfall was on October 15, and our cover crops began to emerge during the week of October 25. Volunteer lentils from the previous year's crop emerged at the same time. We had planned to kill the lentils with herbicide following a moisture event and prior to planting, but the lack of moisture prevented us from implementing that step. We then expected the lentils will be killed by cold winter temperatures, but they survived. We ended up counting the lentils as a weed species in our percent cover and biomass measurements. We terminated the cover crops on May 14 with an application of glyphosate, and planted our commodity crop, which is barley, on May 20 with a Truax no-till range drill (with depth bands removed). We harvested the barley when the grain had 12% moisture on September 9.

Results and Discussion

Cover Crop Percent Cover and Height

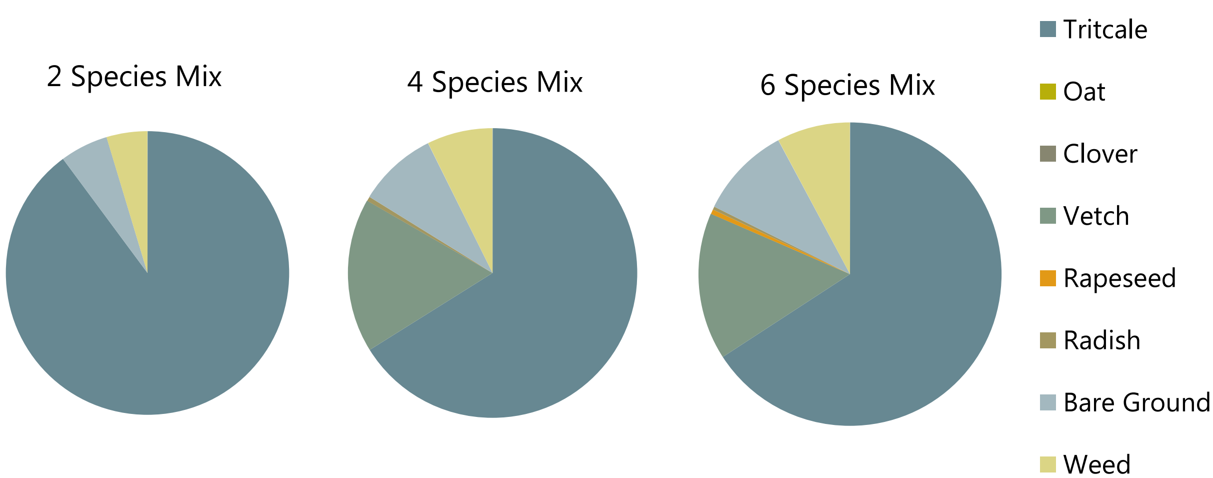
The cover crops grew slowly from the time of emergence in late October through late April. The cover crop growth rate increased significantly during the first week of May, when we experienced record high (over 80° F) temperatures. At the time of cover crop termination on May 14, all cover crops had 90% to 95% cover except the 4 and 6 species plots seeded at the 20 seeds/sq ft seeding rate, which had 85% cover. Weeds in the control plots had 60% cover. Cover crop plant height at the time of termination ranged from 12 inches in the plots with 6 species seeded at the 20 seeds/sq ft seeding rate to 18 inches in the plots with 2 species seeded at the 60 seeds/sq ft seeding rate.

Figure 1. Cover crop plot (4 species mix at 60 seeds/sq ft seeding rate) on April 23, (left) and May 8 (right).

Mix Compositions

Red clover and oat plants established in the fall but did not survive the winter. A small number of rapeseed and radish plants survived the winter and were counted in our percent cover measurements (Figure 2) however their biomass was negligible (Table 1). Triticale was the dominant species in all cover crop plots, with an average of 89% cover in the 2 species plots and 66% cover in the 4 and 6 species plots. The volunteer lentils made up about half of the weed biomass. The percent cover of each mix at the time of termination is diagramed in Figure 2.

Figure 2. Percent cover of cover crop mixes at the time of termination.



Cover Crop Biomass and Percent Nitrogen

Cover crop plots planted to 2 species had about twice the amount of biomass production than plots planted with 4 and 6 species because of their higher triticale composition (Table 1). Biomass production increased with increased seeding rate. Biomass percent nitrogen was lowest in the 2 species mix (2.3%) due to the winter kill of red clover. The 4 and 6 species mixes had slightly higher nitrogen content (2.7% and 2.8% respectively) because they had a hairy vetch

component, and a higher percent lentil volunteer (weed) biomass. Control plot biomass had the highest percent nitrogen (4.1%), being comprised of 50% or more lentil volunteer.

Table 1. Comparisons of average aboveground biomass dry matter, N content, and percent composition of three cover crops mixes and three seeding rates. Values within the same column followed by the same letter are not significantly different in Tukey HSD means comparisons at α = 0.05.

	Dry Matter	% N in Dry	Cover Crop Biomass Composition			
Treatment	(tons/ac)	Matter	Grasses	Legumes	Brassicas	Weeds
2 Species	1.53 a	2.3 c	97% a	0% b	0%	3% b
4 Species	0.88 c	2.7 bc	76% b	9% a	0%	15% b
6 Species	0.73 c	2.8 b	80% b	10% a	0%	12% b
20 seeds/sq ft	0.67 bc	2.8 b	74% a	5% a	0%	21% b
40 seeds/sq ft	1.04 ab	2.5 b	89% a	6% a	0%	5% c
60 seeds/sq ft	1.43 a	2.4 b	89% a	7% a	0%	4% c
Control	0.25 c	4.1 a	.	.	.	100% a

Soil Temperature, Moisture and Nitrate Nitrogen

Cover crops had no effect on soil temperature at the time of commodity crop planting; all plots including the control had a soil temperature around 57°F (Table 2). Cover crop plots with the 20 seeds/sq ft seeding rate had more moisture available than other cover crop plots, however all cover crop plots had 36% to 48% less moisture than the control at the time of commodity crop planting. We observed a similar trend with soil nitrate-nitrogen; all cover crop plots had 30% to 50% less soil nitrate than the control.

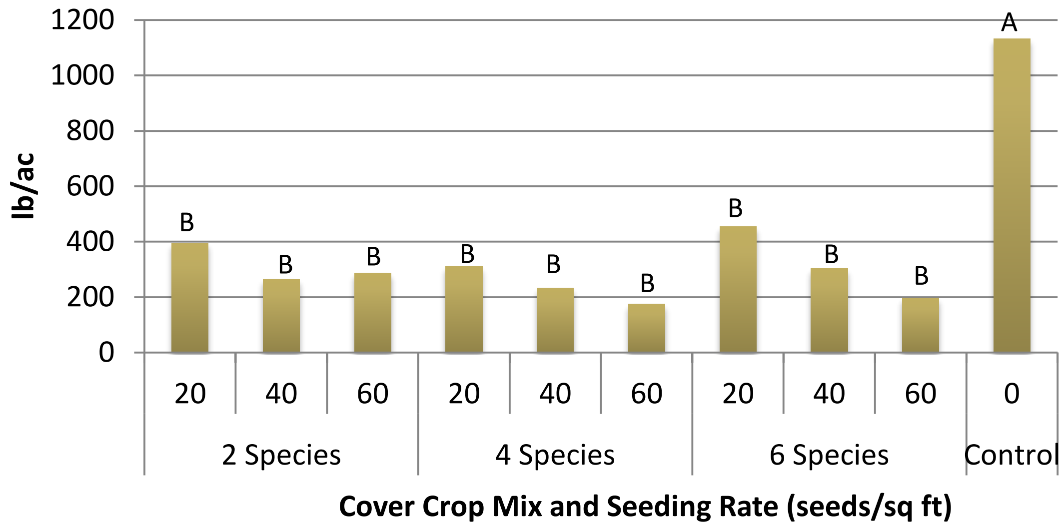
Table 2. Total cover crop biomass at time of termination; soil temperature, moisture and nitrate-nitrogen at the time of commodity crop planting, and barley yield of all cover crop mix combinations.

Cover Crop Mix	Cover Crop Seeding Rate (seeds/sq ft)	Total Biomass (DM t/ac)	Soil Temp (°F)	Soil Moisture (%VWC)	Soil Nitrate (NO_3-N lb/ac)
2 Species	20	0.90	57.7	12.46	24.3
2 Species	40	1.42	57.1	11.38	25.2
2 Species	60	2.27	56.7	11.67	27.4
4 Species	20	0.54	57.0	15.68	28.3
4 Species	40	0.91	57.3	11.92	20.1
4 Species	60	1.19	56.5	11.06	26.9
6 Species	20	0.58	57.4	14.19	28.4
6 Species	40	0.80	57.2	12.50	24.5
6 Species	60	0.82	57.1	12.77	24.0
Control	0	0.25	57.0	21.17	40.3

Commodity Crop Yield

All cover crop plots had significantly lower yield than the control, and there was no significant differences among cover crop mixes and seeding rates (Figure 3). The control had an average yield of 1133 lb/ac, which is about one-fourth of the typical barley yield in our area. Our lower barley yield was most likely a factor of no applied fertilizer and a late planting date.

Figure 3. Average barley yield at 12% moisture (lb/ac) following one season of cover crops. Means with the same letter above the bar are not significantly different in Tukey HSD comparisons at α = 0.05.



Soil Health

One measurement often used to assess soil health is the amount of carbon in the soil. Soil organic carbon (SOC) in our study significantly declined (P>0.00) in all plots from an average of 362 ppm to 219 ppm from the time of cover crop planting to the time of cover crop termination, with no difference in trend among treatments. The C:N ratio also significantly declined (P>0.00) in all plots from an average of 24:1 to 14:1 during the same time period. Lentil residue from the previous year's crop may have increased the soil nitrate and the rate of carbon breakdown, however the cover crop roots, especially from the triticale should have added more carbon to the soil. The soil carbon decline may be explained by seasonal differences, or more time may be needed for a stabilization in the C:N balance to occur.

Dr. Rick Haney (USDA-ARS, Temple, TX) has developed a tool to assess soil health which combines five measurements of soil biological properties into one Soil Health Indicator Value. Values can range on a scale of 0 to 50, and should increase over time if the soil is being sustainably managed. Our soil health indicator values declined slightly from the time of cover crop planting to cover crop termination in all plots except the plots planted to 4 species at the

60 seeds/sq ft rate and the control plots (Figure 4). The slight increase in Soil Health Indicator Value in these plots was likely due to a higher legume component – the hairy vetch in the 4 species plots and the volunteer lentils in the control plots. Neither of the increases in Soil Health Indicator Values are statistically significant, however several of the decreases are (see Figure 4).

Figure 4. Average change in Soil Health Indicator Values of cover crop and control plots from the time of cover crop planting (fall 2012) to the time of termination (spring 2013). Statistically significant changes at the *P*>0.10 level are indicated with an asterisk (*) and at the *P*>0.05 level with two asterisks (**).

Conclusions

Cover crops in this study had minimal growth during the winter months, used significant moisture in the spring, and had detrimental effects on commodity crop yield. In addition, no improvement in soil carbon or soil health was realized after one year of cover crop growth. Many species in the cover crop mixes are not ideal for our region, and different results may be seen if another winter-hardy legume, such as Austrian winter pea, was included. Triticale may not be the most ideal grass component for the mixes due to its aggressive growth and water and nutrient utilization. However, options for a winter-hardy grass alternative are limited. We will continue to monitor the results from this study for the next two years and determine changes in soil health over time.